

JUNE 1999

PROVINCIAL EXAMINATION

MINISTRY OF EDUCATION

GEOLOGY 12

GENERAL INSTRUCTIONS

1. Insert the stickers with your Student I.D. Number (PEN) in the allotted spaces above and on the **back** cover of this booklet. **Under no circumstance is your name or identification, other than your Student I.D. Number, to appear on this booklet.**
2. Ensure that in addition to this examination booklet, you have a **Data Booklet** and an **Examination Response Form**. Follow the directions on the front of the Response Form.
3. **Disqualification** from the examination will result if you bring books, paper, notes or unauthorized electronic devices into the examination room.
4. All multiple-choice answers must be entered on the Response Form using an **HB pencil**. Multiple-choice answers entered in this examination booklet will **not** be marked.
5. For each of the written-response questions, write your answer in **ink** in the space provided in this booklet.
6. When instructed to open this booklet, **check the numbering of the pages** to ensure that they are numbered in sequence from page one to the last page, which is identified by

END OF EXAMINATION.

7. At the end of the examination, place your Response Form inside the front cover of this booklet and return the booklet and your Response Form to the supervisor.

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GEOLOGY 12 PROVINCIAL EXAMINATION

- | | Value | Suggested Time |
|---|------------------|--------------------|
| 1. This examination consists of two parts: | | |
| PART A: 55 multiple-choice questions | 55 | 65 |
| PART B: 11 written-response questions | 45 | 55 |
| Total: | 100 marks | 120 minutes |
- Electronic devices, including dictionaries and pagers, are **not** permitted in the examination room.
 - The **Data Booklet** contains information, graphs, and colour photographs you will need to answer certain questions on this examination.
 - The time allotted for this examination is **two hours**.

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PART A: MULTIPLE CHOICE

Value: 55 marks

Suggested Time: 65 minutes

INSTRUCTIONS: For each question, select the **best** answer and record your choice on the Response Form provided. Using an HB pencil, completely fill in the circle that has the letter corresponding to your answer.

1. The elements that make up the largest percentage of the earth's crust are
- A. iron and calcium.
 - B. oxygen and silicon.
 - C. aluminum and iron.
 - D. silicon and aluminum.

**REFERENCE
DATA BOOKLET**

Refer to page vi of the Data Booklet.

Use Photograph 1 and the following table to answer questions 2 and 3.
The photograph shows two *different* minerals.

Object	MOHS Scale of Hardness
Glass or steel knife	5.5
Wire nail	4.5
Copper penny	3.5
Fingernail	2.5

2. The minerals shown in the photograph have the same lustre and similar colours. Mineral **Y** will scratch glass. Mineral **Y** is **most likely**
- A. pyrite.
 - B. galena.
 - C. hematite.
 - D. chalcopyrite.
3. Mineral **X** is mined in B.C. and can be scratched by a wire nail. It is an important ore of
- A. zinc.
 - B. lead.
 - C. gold.
 - D. copper.

4. Halite and calcite can both occur as clear crystals. The best property to distinguish between these two minerals would be
- A. lustre.
 - B. streak.
 - C. colour.
 - D. cleavage.

**REFERENCE
DATA BOOKLET**

**Refer to page vi of the Data Booklet.
Use Photograph 2 to answer question 5.**

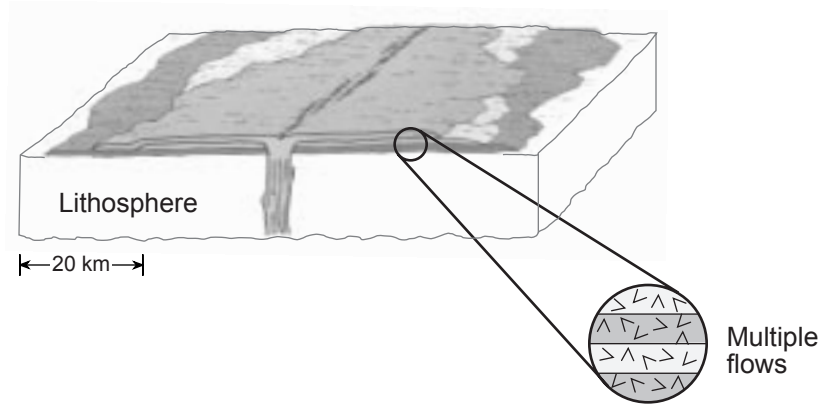
5. The igneous rock shown in the photograph is **most likely**
- A. gabbro.
 - B. granite.
 - C. rhyolite.
 - D. andesite.

**REFERENCE
DATA BOOKLET**

**Refer to page x of the Data Booklet.
Use the Percentage of Minerals in Igneous Rocks table
to answer question 6.**

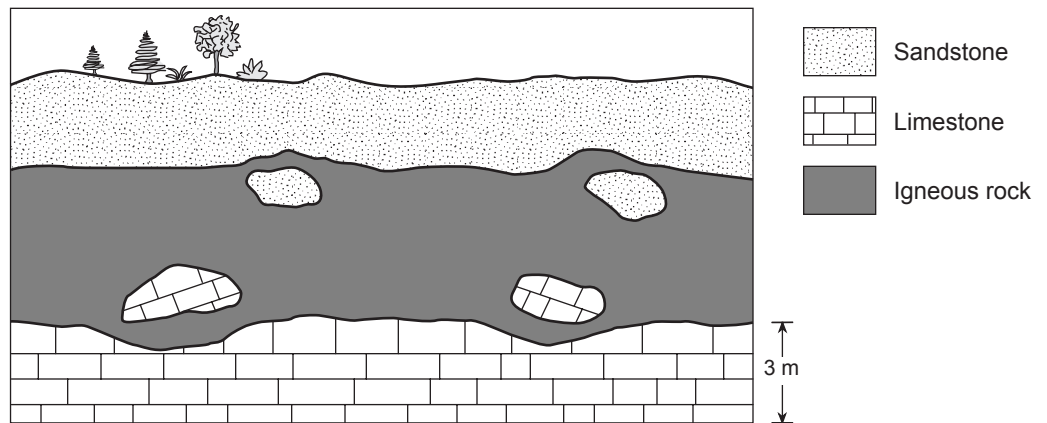
6. A fine-grained igneous rock, when examined using a microscope, is found to contain 30% dark ferromagnesian minerals. Which other minerals would you expect to find in this rock?
- A. plagioclase feldspar only
 - B. plagioclase feldspar and muscovite
 - C. potassium feldspar, muscovite and quartz
 - D. plagioclase feldspar, potassium feldspar and quartz

Use the following sketch of a volcanic feature to answer question 7.



7. The lava that produced the volcanic feature shown in the sketch is **most likely**
- A. mafic with high viscosity.
 - B. basaltic with low viscosity.
 - C. andesitic with low viscosity.
 - D. rhyolitic with high viscosity.

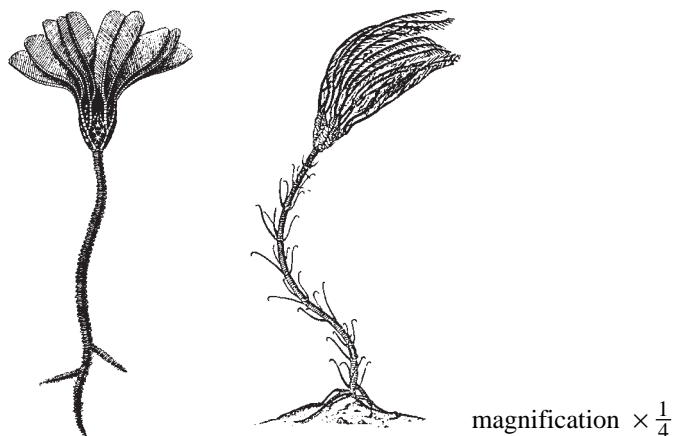
Use the following cross-section diagram to answer question 8.



8. The igneous layer in the cross section is best described as a
- A. sill.
 - B. dike.
 - C. stock.
 - D. buried lava flow.

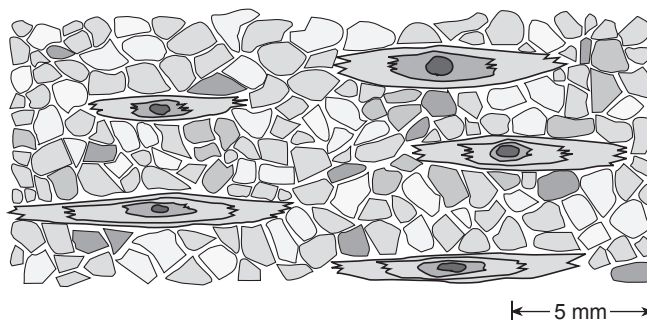
9. In which of the following sedimentary environments were the materials which form the rock shown in the photograph **most likely** deposited?
- A. river delta
 - B. talus slope
 - C. desert dune
 - D. lake bottom

Use the following diagrams to answer question 10.



10. Which of the following sedimentary rocks would **most likely** contain the fossils shown in the diagram above?
- A. breccia
 - B. gypsum
 - C. limestone
 - D. conglomerate
-
11. The metamorphic rock that forms under the lowest temperature and lowest pressure conditions is
- A. slate.
 - B. schist.
 - C. gneiss.
 - D. phyllite.

Use the following sketch of the texture of a metamorphic rock to answer question 12.



12. Which directions of maximum compressive stress **most likely** caused the alignment of the elongate crystals in the metamorphic rock?

A. $\Rightarrow \Leftarrow$

B. $\Leftarrow \Rightarrow$

C. \Uparrow
 \Downarrow

D. \Downarrow
 \Uparrow

**REFERENCE
DATA BOOKLET**

Refer to page i of the Data Booklet.
Use the Geologic Cross Section to answer question 13.

13. The metamorphic rock that has formed at location **P** in the cross section will **most likely** be

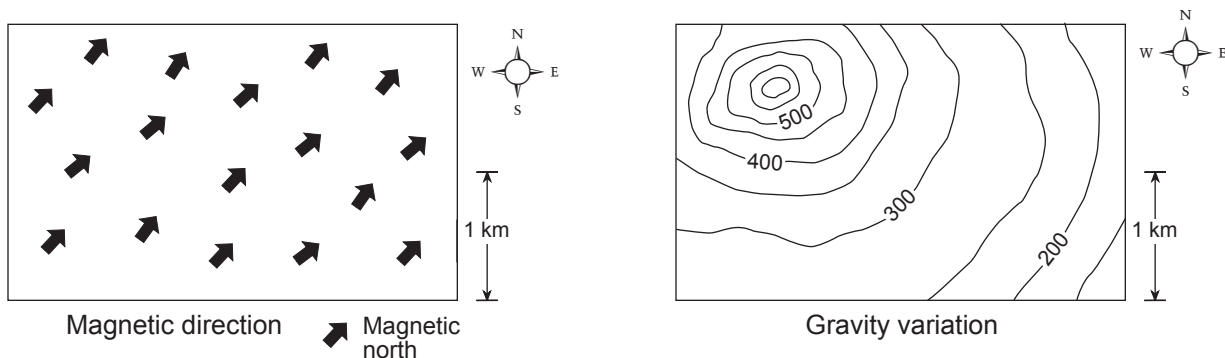
- A. foliated schist.
- B. foliated marble.
- C. nonfoliated phyllite.
- D. nonfoliated quartzite.

Refer to page xii of the Data Booklet.

Use the Property of Common and Important Minerals table and the following sketch maps to answer questions 14 and 15.

The maps show the magnetic field direction and the variation of gravity over the same area.

The numbered lines on the gravity map join points of equal gravitational field strength; higher numbers show greater strength.



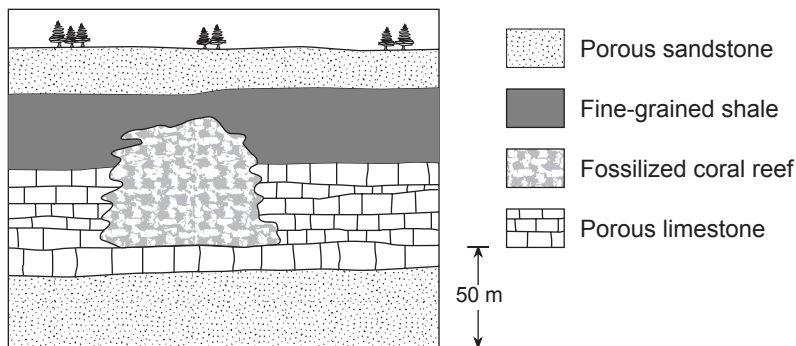
14. The **most likely** area of mineral concentration would be in the

- A. northeast quadrant.
- B. southeast quadrant.
- C. northwest quadrant.
- D. southwest quadrant.

15. The mineral indicated by the data provided is **most likely**

- A. quartz.
- B. galena.
- C. asbestos.
- D. magnetite.

Use the following cross-section sketch of a possible oil reservoir to answer question 16.



16. Which of the layers shown in the diagram would form the best **cap rock** for an oil reservoir?

- A. porous limestone
- B. porous sandstone
- C. fine-grained shale
- D. fossilized coral reef

17. The following table shows four types of coal, with typical values for the percentage of carbon, hydrogen and oxygen in each. Which type of coal would have experienced the **greatest** degree of metamorphism?

	Type of Coal	% Carbon	% Hydrogen plus Oxygen
A.	Lignite	60	36
B.	Sub-bituminous	70	27
C.	Bituminous	80	17
D.	Anthracite	90	8

18. The statement “the granite is younger than the limestone” is an example of

- A. correlation.
- B. relative dating.
- C. absolute dating.
- D. uniformitarianism.

OVER

**REFERENCE
DATA BOOKLET**

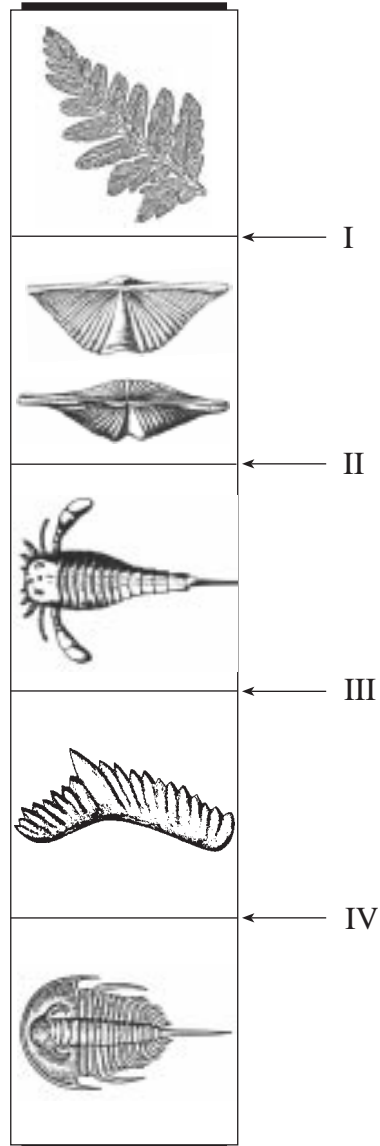
Refer to pages i and ii of the Data Booklet.
**Use the Geologic Cross Section and the Geological Time Scale
to answer questions 19 and 20.**

19. From the evidence shown in the cross section, which of the following could **not** be used to determine the relative ages of the sandstone and shale layers?
- A. correlation
 - B. superposition
 - C. included fragments
 - D. original horizontality
20. In which geological era was the shale **likely** deposited?
- A. Cenozoic
 - B. Mesozoic
 - C. Paleozoic
 - D. Precambrian

**REFERENCE
DATA BOOKLET**

Refer to pages ii and iii of the Data Booklet.

Use the Geological Time Scale and the Fossil Samples, along with the following cross-section diagram showing rock layers to answer question 21.



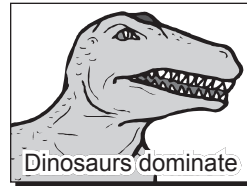
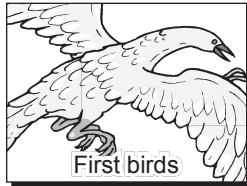
21. In the cross section above, which of the four contacts **must** represent an unconformity?

- A. I
- B. II
- C. III
- D. IV

22. After a period of three half-lives, a sample of rock has 10 micro-grams of radioactive material left. How many micro-grams of radioactive material did it start with?

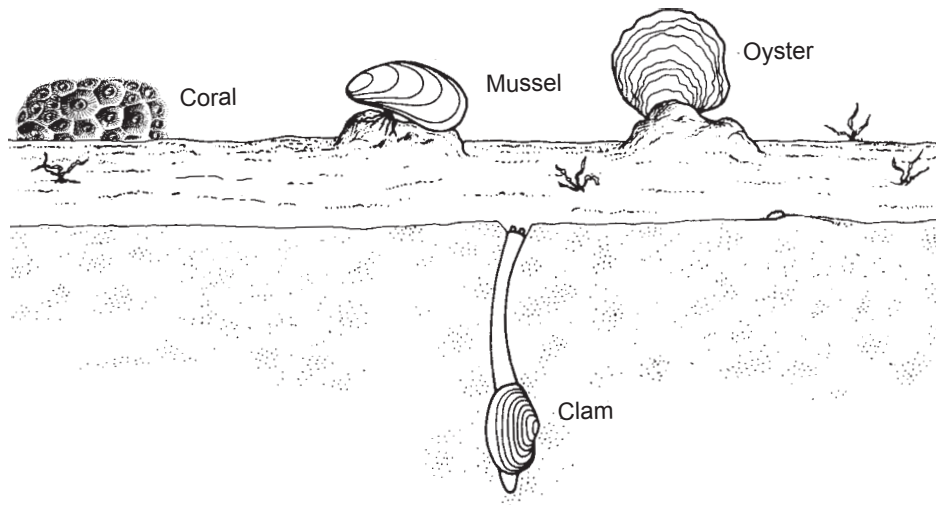
- A. 30
- B. 40
- C. 60
- D. 80

23. In which geological era did all of the following events occur?



- A. Cenozoic
- B. Mesozoic
- C. Paleozoic
- D. Precambrian

Use the following diagram to answer question 24.



24. Of the organisms shown above, the one **most likely** to leave a trace fossil is the

- A. clam.
- B. coral.
- C. oyster.
- D. mussel.

25. The photograph shows fossil coral which was found in limestone. When broken in half, the fossil showed clear details of its internal structure. Which of the following is the **most likely** means of preservation in this example?
- A. cast
 - B. mold
 - C. carbonization
 - D. as original material

Use the following list to answer question 26.

- 1. Long time range.
 - 2. Short time range.
 - 3. Geographically widespread.
 - 4. Confined to one geographic area.
26. The characteristics of a good index fossil are an easily identifiable form in addition to
- A. 1 and 3
 - B. 1 and 4
 - C. 2 and 3
 - D. 2 and 4

**REFERENCE
DATA BOOKLET**

Refer to pages ii and v of the Data Booklet.

Use the Geological Time Scale and the Development of Life Through Time chart to answer question 27.

27. A geologist has found the following assemblage of fossils in a shale layer.

Graptolites

Trilobites

Brachiopods

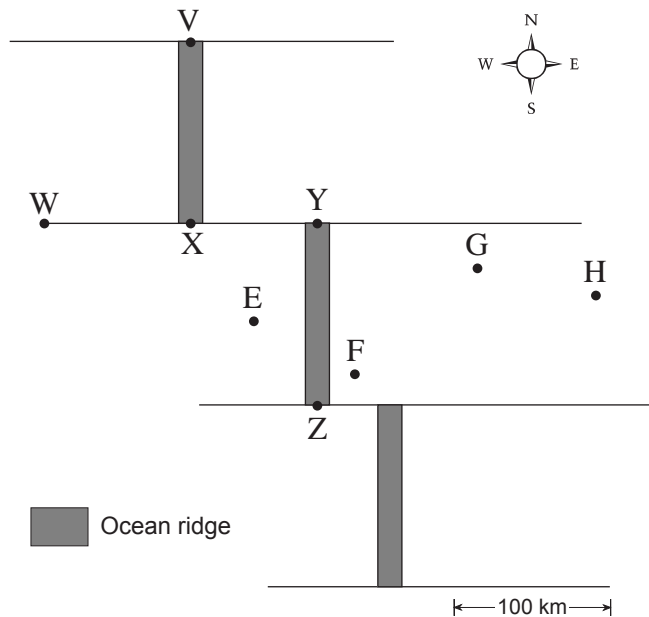
The **most likely** age of the shale layer is

- A. Permian.
 - B. Devonian.
 - C. Ordovician.
 - D. Precambrian.
-

28. Which of the following life forms must have evolved before the others?

- A. coral
- B. algae
- C. trilobites
- D. brachiopods

Use the following map of plate boundaries in oceanic lithosphere to answer questions 29 to 32.

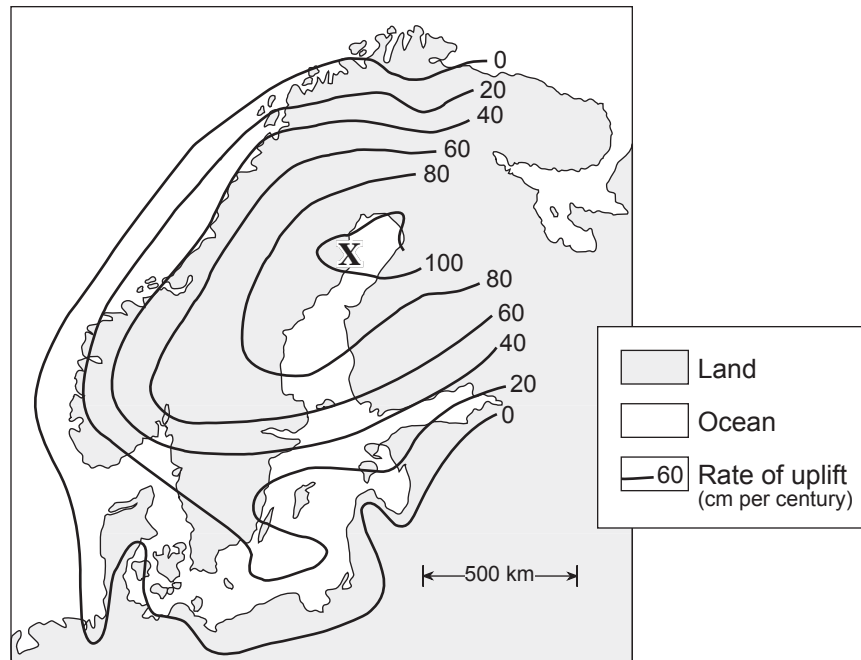


29. The type of plate boundary shown between **X** and **Y** is
- diverging.
 - transform.
 - subduction.
 - converging.
30. Which of the following rock types is **most likely** found at the centre of the ridges?
- rhyolite tuff
 - organic shale
 - basalt pillows
 - organic limestone
31. Ocean floor sediments have been drill-sampled down to bedrock at locations E, F, G and H. The **most likely** location to have the **thickest sediment** deposit is
- E
 - F
 - G
 - H
32. The segment of oceanic lithosphere that would experience the **least** amount of seismic activity is between
- V and X
 - W and X
 - X and Y
 - Y and Z

OVER

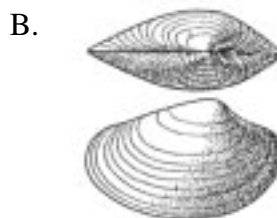
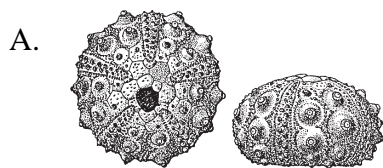
33. Some of the world's mountain belts, such as the Rockies, are not along active earthquake belts. This observation seems to contradict the idea that plate collisions can create mountains. A likely explanation of this observation is that these mountains
- A. are thick deposits of basalt.
 - B. were formed by layers of sediment.
 - C. are the sites of ancient collision boundaries.
 - D. are points where new plate boundaries are forming.
34. A low energy earthquake that caused most of the buildings in a town to collapse would be rated
- A. low on the Richter scale and low on the Mercalli scale.
 - B. low on the Richter scale and high on the Mercalli scale.
 - C. high on the Richter scale and low on the Mercalli scale.
 - D. high on the Richter scale and high on the Mercalli scale.
35. Which of the following is the **least** useful for predicting earthquakes?
- A. height of sea level
 - B. amount of ground tilt
 - C. degree of micro-seismic activity
 - D. percentage of radon in ground water
36. A magnitude 8 earthquake located 20 kilometres off the west coast of Vancouver Island would likely produce all of the following **except**
- A. a tsunami.
 - B. landslides.
 - C. a volcanic eruption.
 - D. liquefaction of sediments.
37. Movement along a fault without the buildup of significant amounts of stress is known as
- A. creep.
 - B. strain.
 - C. stress rupture.
 - D. elastic rebound.

Use the following map which shows rates of crustal uplift in Scandinavia to answer question 38.
The numbered lines join points of equal crustal uplift.



38. At location **X**, the crust is rising
- A. fastest because this is where the Pleistocene ice cap was the thickest.
 - B. fastest because this is where the Pleistocene ice cap was the thinnest.
 - C. slowest because this is where the Pleistocene ice cap was the thickest.
 - D. slowest because this is where the Pleistocene ice cap was the thinnest.
-
39. The layer of the earth that is solid, has the lowest seismic velocities and is composed of silicate material is the
- A. crust.
 - B. mantle.
 - C. outer core.
 - D. inner core.

40. The orientation of the strata shown on the Geological Map is
- A. strike east, dip 30 degrees north.
 - B. strike south, dip 30 degrees east.
 - C. strike north, dip 30 degrees west.
 - D. strike west, dip 30 degrees south.
41. Which of the following fossils would **most likely** be found in the black shale layer on the Geological Map?

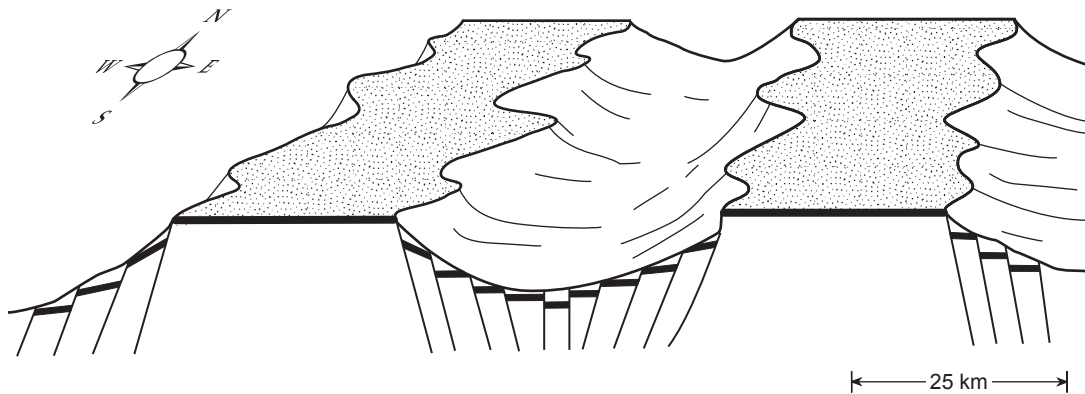


42. The movement along structure **X** on the Geological Map is entirely **vertical**. Structure **X** is **most likely** a
- A. joint.
 - B. dip-slip fault.
 - C. unconformity.
 - D. strike-slip fault.

43. The vertical fractures shown in the photograph are

- A. joints produced by expansion.
- B. faults produced by expansion.
- C. joints produced by contraction.
- D. faults produced by contraction.

Use the following diagram to answer question 44.



44. The structures shown in the diagram **most likely** formed at a boundary where the plates were

- A. moving apart.
- B. rising upwards.
- C. coming together.
- D. sliding past each other.

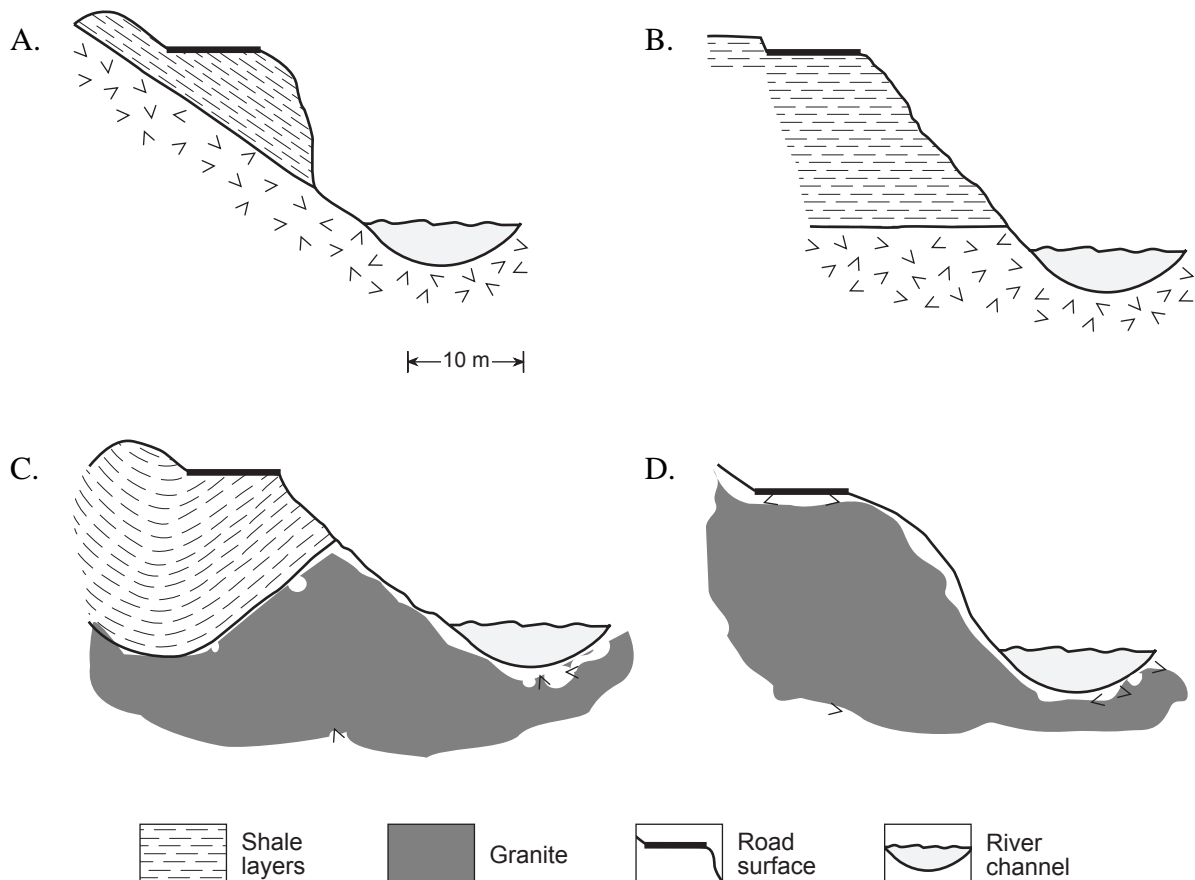
Use the following list of processes to answer question 45.

- Ice wedging
- Root wedging
- Exfoliation

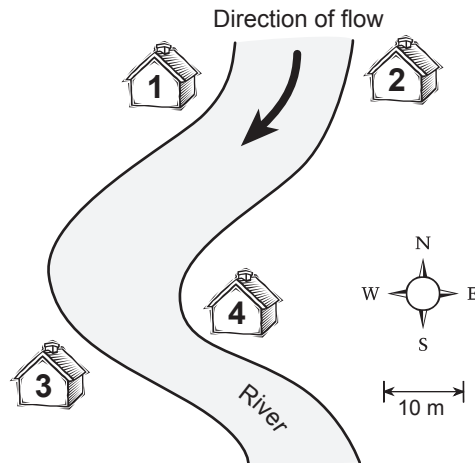
45. All of the processes above can be classified as

- A. hydrolysis.
 - B. lithification.
 - C. mass wasting.
 - D. mechanical weathering.
-

46. Which of the following diagrams illustrates the **greatest** potential for failure of the slope above the river?



Use the following diagram which shows a river meander and four cottages to answer question 47.



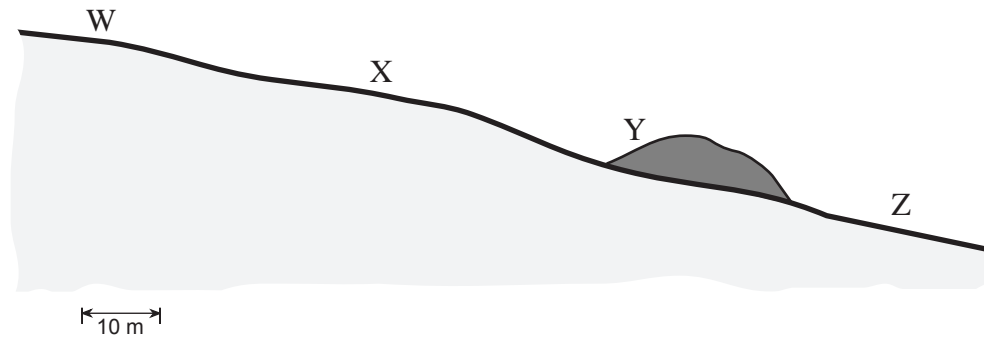
47. Which of the four cottages is in the **greatest** immediate danger from river erosion?
- A. 1
 - B. 2
 - C. 3
 - D. 4

**REFERENCE
DATA BOOKLET**

Refer to page viii of the Data Booklet.
Use Photograph 6 to answer question 48.

48. The sediment in the photograph was **most likely** transported by
- A. wind.
 - B. waves.
 - C. a river.
 - D. a glacier.
-
49. What is the **best** information that glacial striations can provide geologists?
- A. The exact date of glaciation.
 - B. The thickness of the ice sheet.
 - C. The speed the glacier was moving.
 - D. The direction of the glacier's flow.

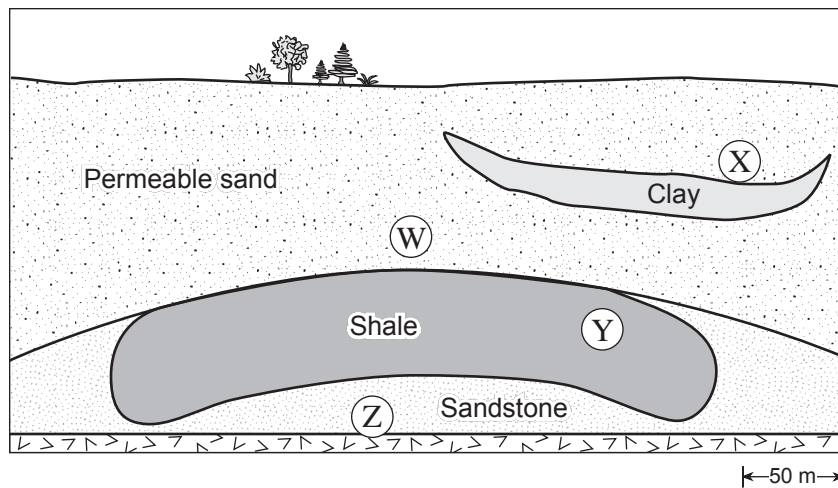
Refer to the cross section below of a terminal moraine to answer question 50.



50. The terminal moraine was deposited by the only glacier in the area. In which of the following locations would erratics **least likely** be found?

A. W
B. X
C. Y
D. Z

Refer to the following cross-section sketch to answer question 51.



51. Which of the following is the **most likely** location for a perched water table?

A. W
B. X
C. Y
D. Z

52. A well that produces a reliable, year-round supply of water must reach
- A. into impermeable bedrock.
 - B. just above the zone of saturation.
 - C. only as far as the zone of aeration.
 - D. below the lowest level of the water table.
53. The most heavily cratered solid bodies in the solar system also have the
- A. deepest oceans.
 - B. thickest atmospheres.
 - C. least tectonic activity.
 - D. highest internal temperatures.
54. Which of the following solar system bodies shows evidence of flowing water at some time in its history?
- A. Mars
 - B. Moon
 - C. Venus
 - D. Jupiter
55. The Nebular Model of the origin of the solar system suggests that the outer planets consist of lighter, easily evaporated materials because these materials would condense where
- A. pressures were lower.
 - B. pressures were higher.
 - C. temperatures were lower.
 - D. temperatures were higher.

This is the end of the multiple-choice section.
Answer the remaining questions directly in this examination booklet.

OVER

PART B: WRITTEN RESPONSE

Value: 45 marks

Suggested Time: 55 minutes

INSTRUCTIONS: Answer each question in the space provided. You may not need to use all of the space given.

1. The element of “time” makes geology unique from other science disciplines. Some geological processes occur at such slow rates that they are almost imperceptible, while others are very rapid. Describe a geological process that occurs at a slow rate and a geological process that occurs at a rapid rate. Include an appropriate rate with correct units for each process.

(3 marks)

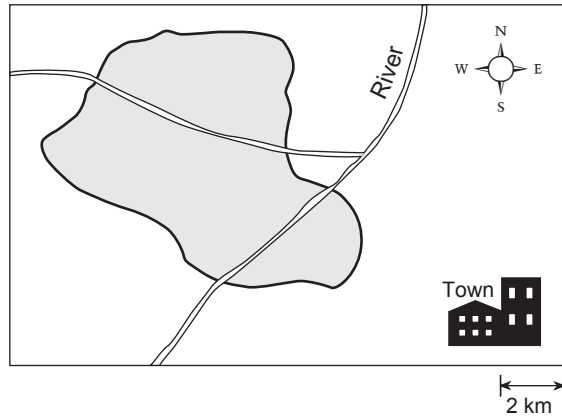
- a) i) Geological process that occurs at a slow rate:

- ii) Appropriate rate with correct units: _____

- b) i) Geological process that occurs at a rapid rate:

- ii) Appropriate rate with correct units: _____

Use the following sketch map to answer question 2.



2. The shaded area shown on the map represents fractured volcanic rock that has been intruded and altered by mineral veins. Exploration of the area has found concentrations of chalcopyrite, galena and sphalerite.

a) Name and describe the process **most likely** responsible for the formation of this deposit.

(2 marks)

Name: _____

Description: _____

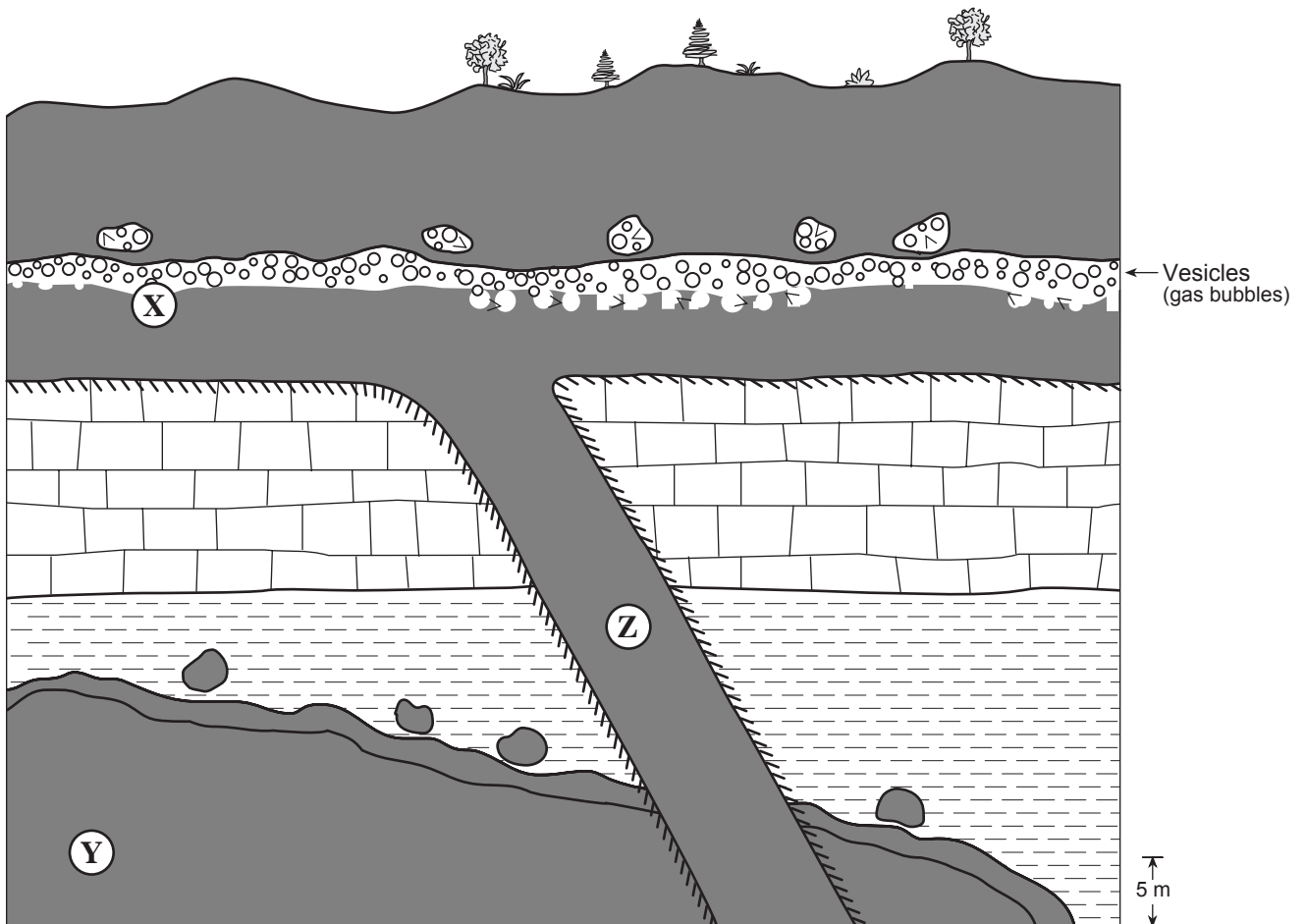
b) Describe **two** specific factors that must be considered before developing a mine in the area.








(2 marks)

i) _____

ii) _____

Use the cross-section diagram below to answer question 3.



	Conglomerate		Limestone		Shale
	Coarse-grained igneous rock		Fine-grained igneous rock		
	Pitted, rusty alteration to the igneous rock		Contact metamorphism		

3. a) Describe **two** features, visible in the cross section, which show that the contact between rock unit **Y** and the shale is an erosion surface. **(2 marks)**

i) _____

ii) _____

b) The fine-grained rock unit **X** has been identified as a lava flow. (2 marks)

i) Explain how the gas bubbles present show that rock unit **X** is not a sill.

ii) Describe **one** other piece of evidence that could be used to show that rock unit **X** is not a sill.

c) Rock unit **Z** shows a difference in crystal sizes across its width. (2 marks)

i) Describe a **specific** location where the smallest crystals would be found and explain why they would be found there.

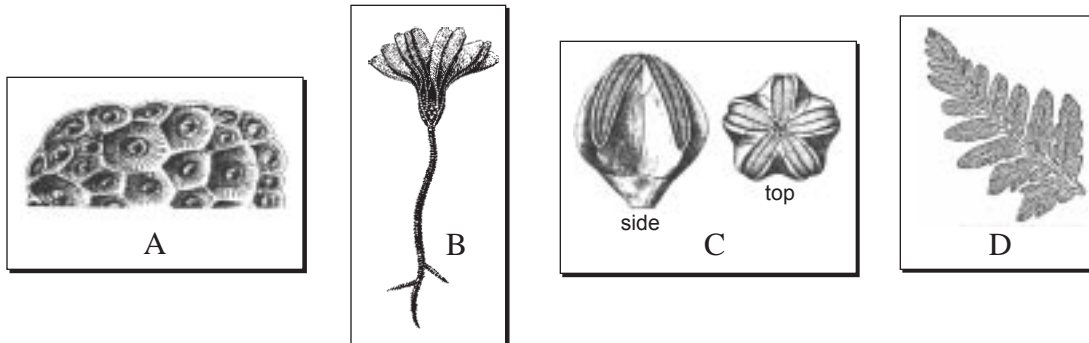
Location: _____

Explanation: _____

d) Describe a change that could be observed in the texture of the limestone at its contact with rock unit **X**. (1 mark)

Refer to pages ii and iii of the Data Booklet.
Use the Geological Time Scale and Fossil Samples to answer question 4.

4. The following four fossils are in a collection.



a) Which fossil seems out of place with the others? _____ **(1 mark)**

b) Give **two** reasons for your conclusion in a) above. **(2 marks)**

i) _____

ii) _____

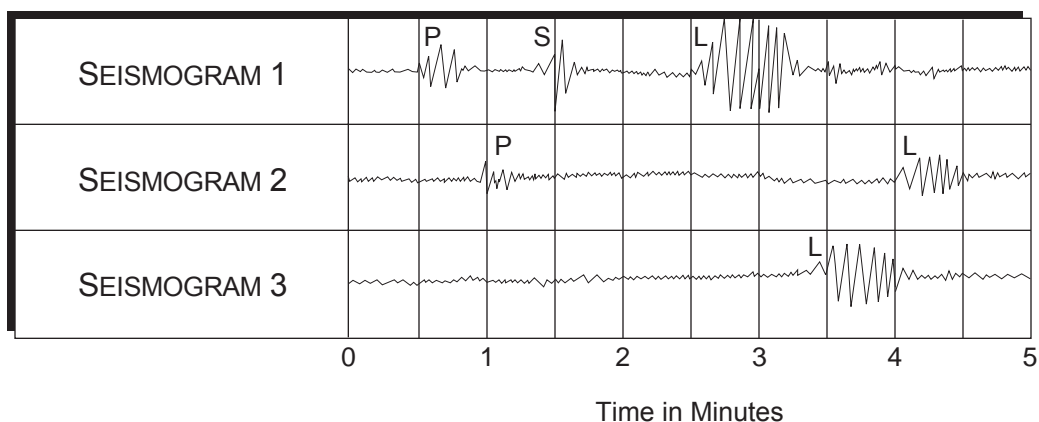
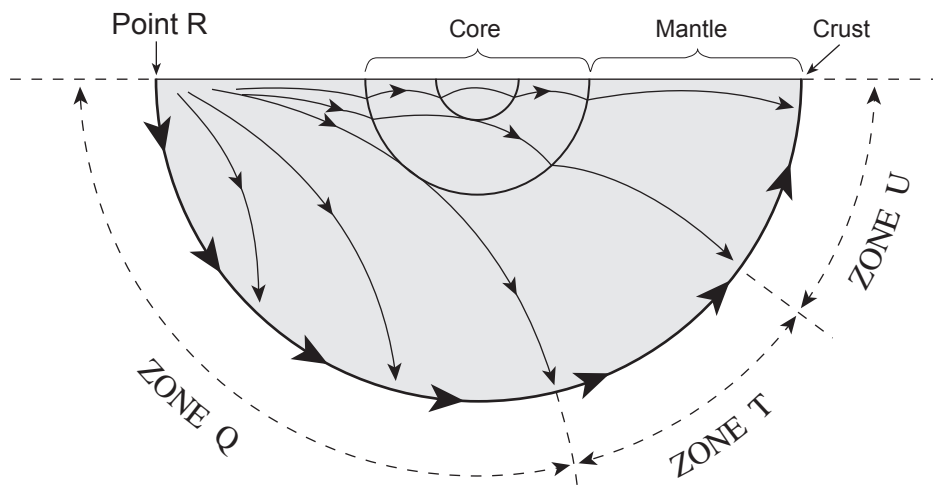
c) What is the maximum time-span, in millions of years, represented by this fossil collection? **(1 mark)**

5. a) On the grid below, sketch a radioactive decay curve for an element with a half-life of 2 million years. Your sketch must contain: **(3 marks)**
- Appropriately labelled vertical and horizontal axes.
 - Smooth and clearly drawn decay curve for four half-lives.



- b) Describe **one** problem associated with radiometric dating of a heavily-weathered conglomerate. **(1 mark)**

Use the following cross section of the earth and seismograms 1, 2 and 3 to answer question 6.



6. The diagram shows part of a cross section through the earth together with some typical paths taken by seismic waves from an earthquake at point **R**. Seismometers set up in each of the three zones, **Q**, **T** and **U**, produced the three seismograms that are shown for this earthquake.

a) What is the difference in arrival times of the P-waves between seismograms 1 and 2? (1 mark)

b) Describe **one** other difference in the recorded P-waves that you can see between seismograms 1 and 2. (1 mark)

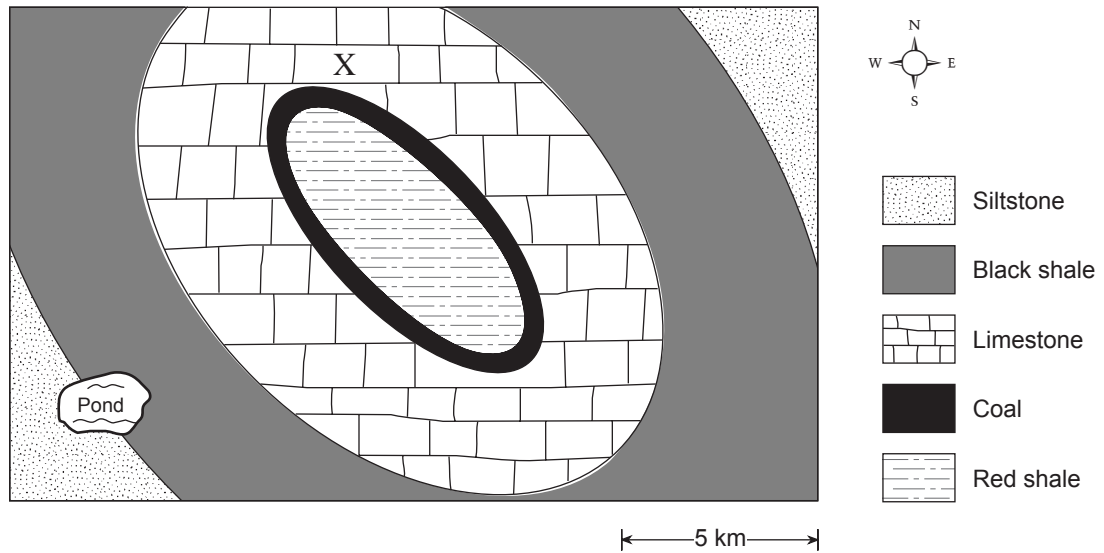
c) Suggest a reason for the differences identified in a) and b). **(1 mark)**

d) Explain why seismometer 2 did not receive any S-waves. **(1 mark)**

e) Which seismogram was obtained from zone **T**? _____ **(1 mark)**

f) Which of the three types of seismic waves (P, S or L) follows the path around the earth's surface? **(1 mark)**

Use the following sketch map of a geological structure to answer question 7.



7. The geological structure shown in the sketch map is either a dome or a basin.

a) Give evidence involving:

(2 marks)

- i) the dip and strike of the strata, and
- ii) the ages of the strata

that a geologist could look for to prove whether the structure is a dome or a basin.

i) Evidence using the dip and strike of the strata:

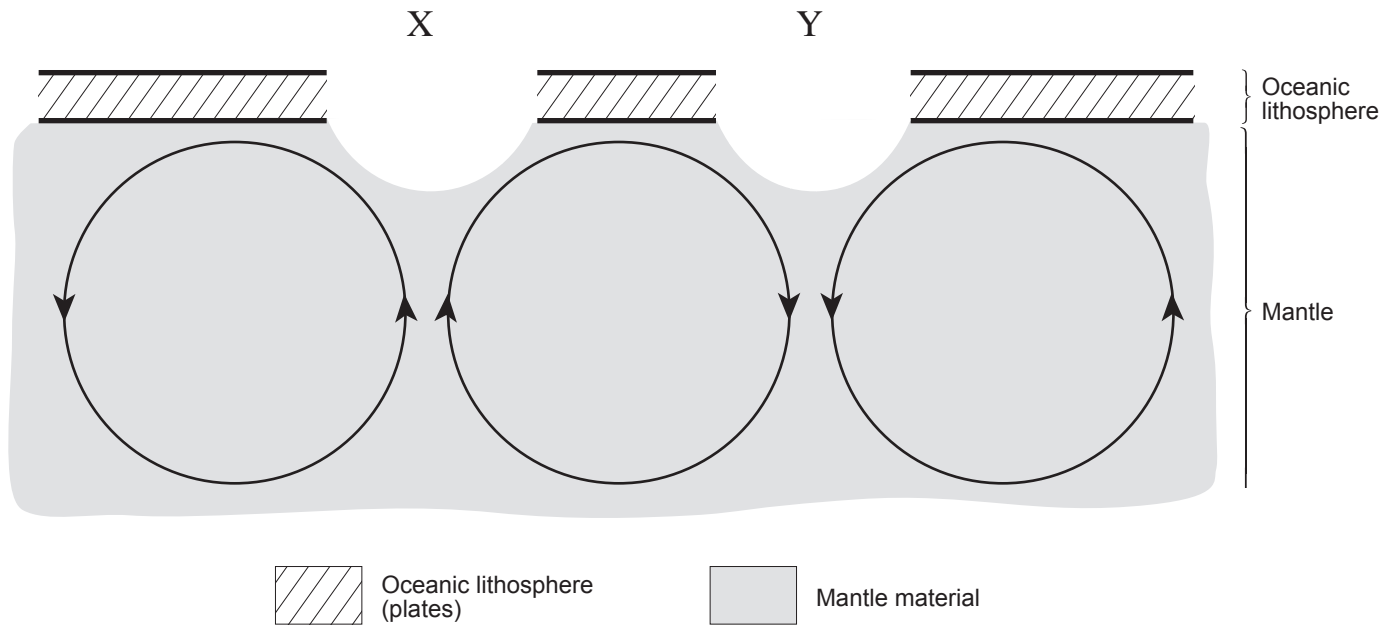
ii) Evidence using the ages of the strata:

- b) A vertical hole drilled at location **X** on the structure encountered three different rock strata. Assuming that the structure is a **dome**, sketch, in the space provided below, the first three strata that would be encountered in the drill hole. **(1 mark)**

Drill hole



Use the following cross section of three mantle convection currents and part of the oceanic lithosphere to answer question 8.

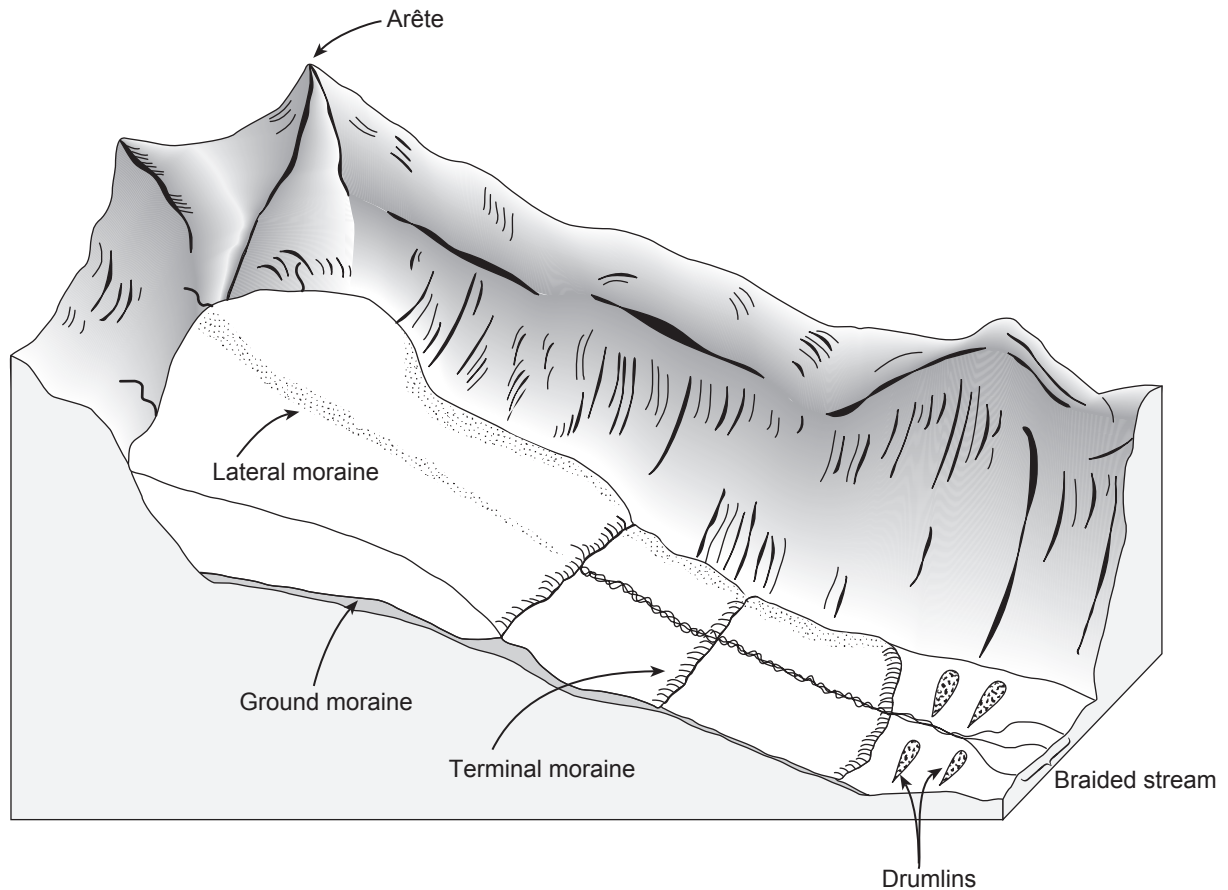


8. a) Explain what causes the mantle convection currents to rise and then fall. **(1 mark)**

- b) Complete the oceanic plates appropriately in the gaps below **X** and **Y**. Label with arrows showing the direction of movement. **(2 marks)**

- c) On the completed diagram, label an ocean trench and a rift valley. **(1 mark)**

Use the following cut-away sketch of a glacier in a valley to answer question 9.



9. The sketch above was drawn from memory by a geology student. A few errors were made in the details and the labelling of the sketch. Name **four** such errors, and describe how the drawing could be corrected. (4 marks)

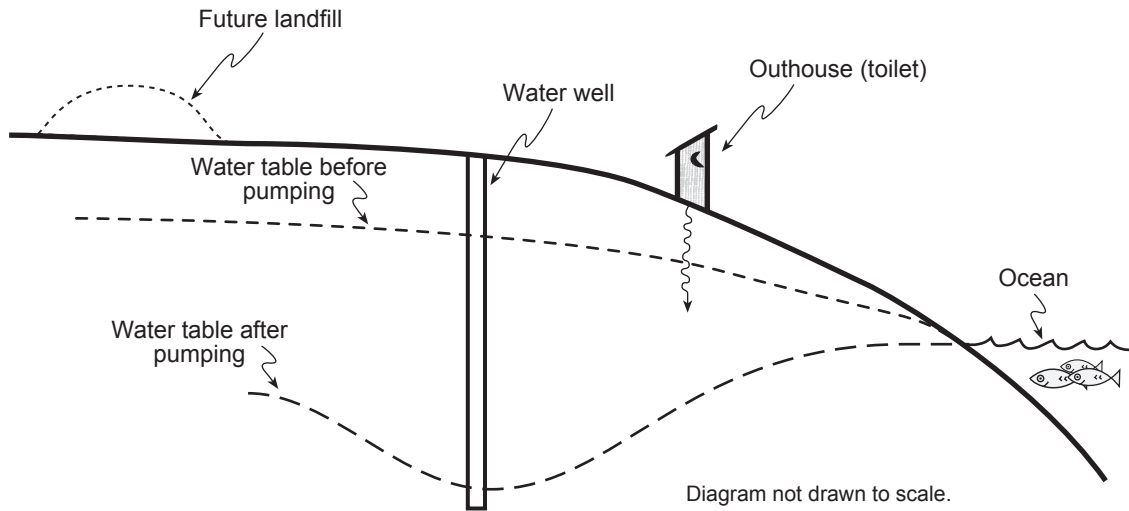
Error 1 and correction: _____

Error 2 and correction: _____

Error 3 and correction: _____

Error 4 and correction: _____

Use the following cross section of a water well to answer question 10.



10. a) The people using the water well in the diagram above should be very concerned about the quality of their water supply. Describe **two** existing problems for a well in this location.

(2 marks)

i) _____

ii) _____

- b) What measures could be taken to prevent material from the future landfill site from leaching into the water supply?

(1 mark)

11. Describe **three** characteristics of the planets of our solar system, other than distance from the sun, that justify their classification into inner and outer groups. As there is some question at this time whether Pluto is a planet, omit Pluto from your answer. **(3 marks)**

	CHARACTERISTIC	INNER PLANETS	OUTER PLANETS
	Example: <i>Distance from the sun.</i>	<i>Four inner planets are closer to the sun.</i>	<i>Outer planets are farther away from the sun than inner planets are.</i>
1.			
2.			
3.			

END OF EXAMINATION

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← INSERT STUDENT I.D. NUMBER (PEN) ←

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GEOLOGY 12

June 1999

Course Code = GEOL

FOR OFFICE USE ONLY

GEOLOGY 12

June 1999

Course Code = GEOL

Score for
Question 1:

1. _____
(3)

Score for
Question 8:

8. _____
(4)

Score for
Question 2:

2. _____
(4)

Score for
Question 9:

9. _____
(4)

Score for
Question 3:

3. _____
(7)

Score for
Question 10:

10. _____
(3)

Score for
Question 4:

4. _____
(4)

Score for
Question 11:

11. _____
(3)

Score for
Question 5:

5. _____
(4)

Score for
Question 6:

6. _____
(6)

Score for
Question 7:

7. _____
(3)

DATA BOOKLET

Geology 12

JUNE 1999

Acknowledgements for Photographs

PHOTOGRAPH 1
JLM Visuals

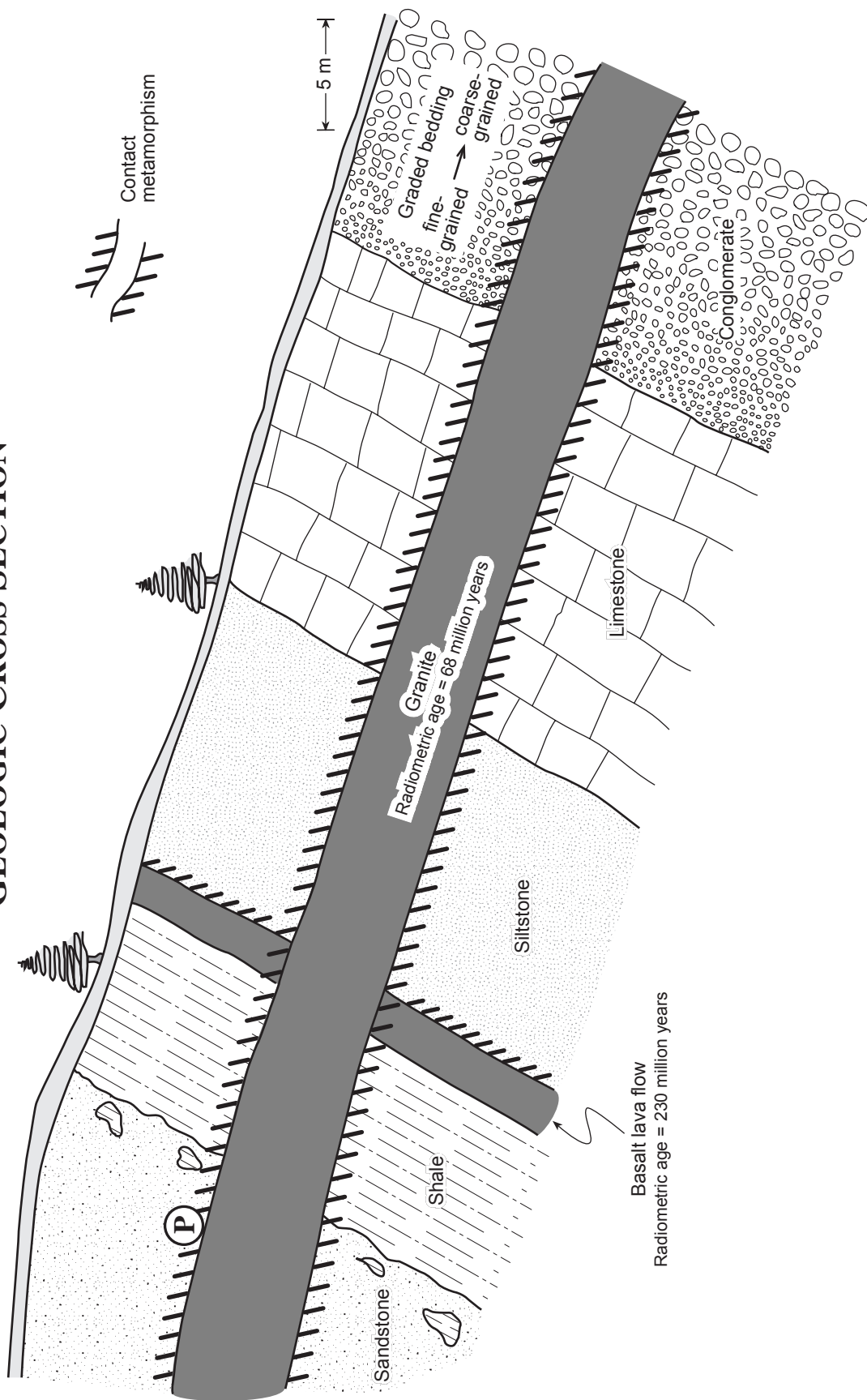


PHOTOGRAPHS 3, 4 AND 6
Mining Association of BC



PHOTOGRAPHS 2 AND 5
A. Sedgwick

GEOLOGIC CROSS SECTION



GEOLOGICAL TIME SCALE



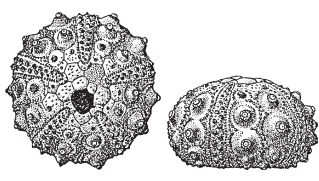



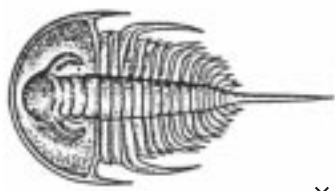

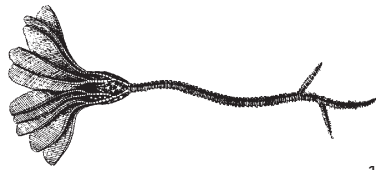
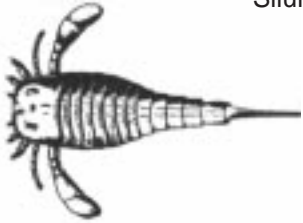

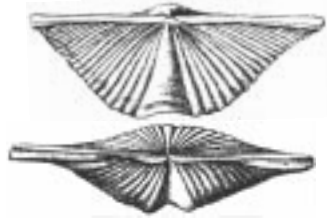
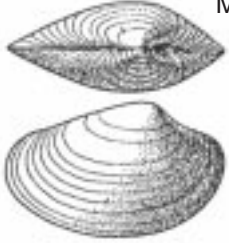
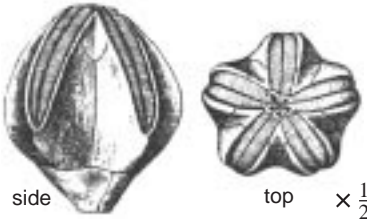



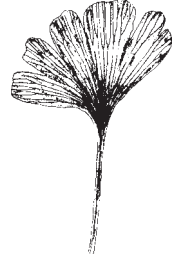
ERA	PERIOD		EPOCH	TIME m.y.
Cenozoic	Quaternary		Holocene	0.01
			Pleistocene	2
	Tertiary		Pliocene	5
			Miocene	24
			Oligocene	37
			Eocene	58
			Paleocene	66
Mesozoic	Cretaceous			144
	Jurassic			208
	Triassic			245
Paleozoic	Permian			286
	Carboniferous	Pennsylvanian		320
		Mississippian		360
	Devonian			408
	Silurian			438
	Ordovician			505
	Cambrian			570
Precambrian				4000*

Based on Hamblin, *The Earth's Dynamic Systems*, 1982. Dates from Montgomery, *Physical Geology*, 1987.

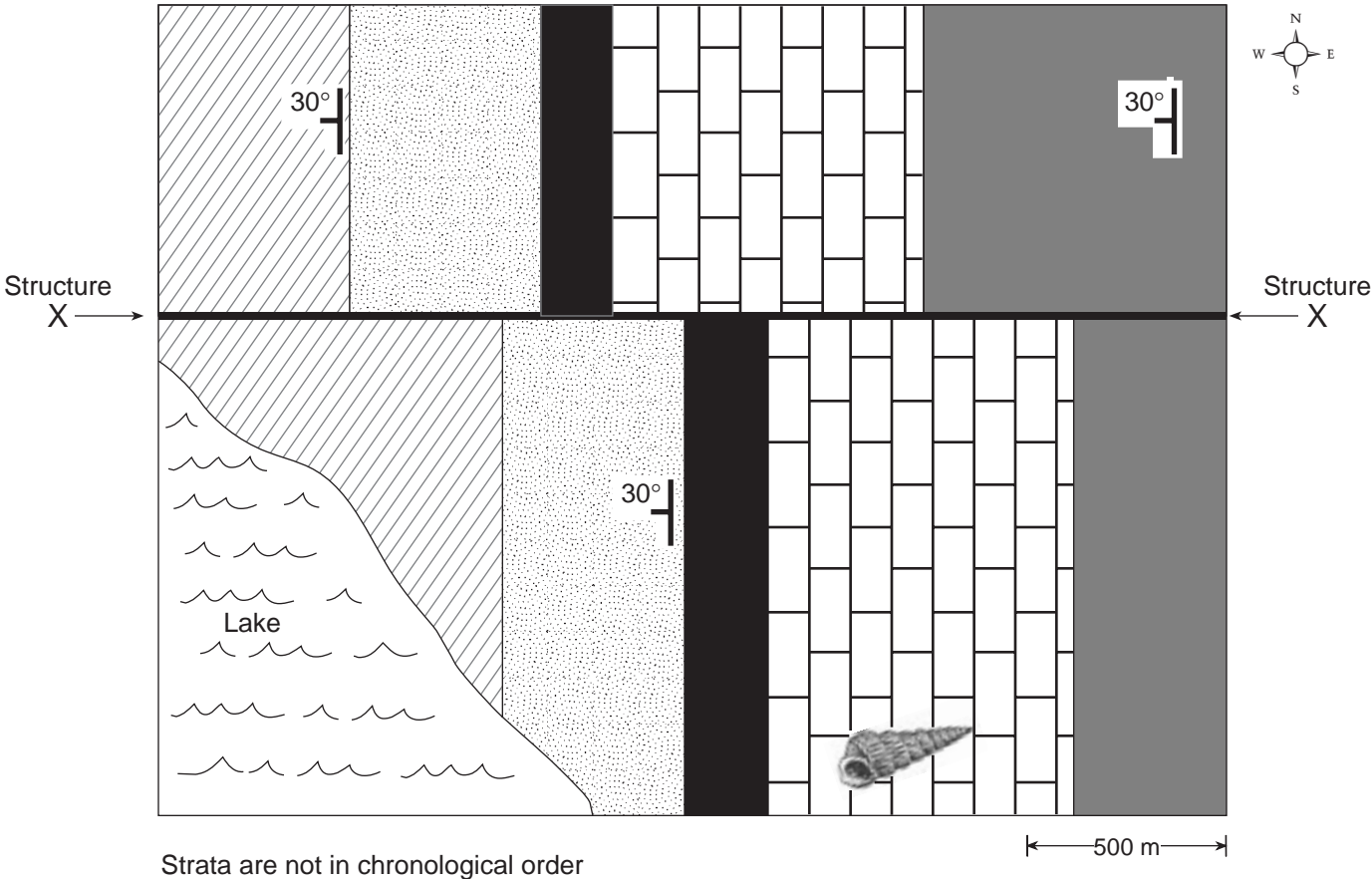
It is recognized that there is some variation in the dates given in the literature.

*Approximate age of the oldest rocks.

FOSSIL SAMPLES

<p>1</p>  <p>Tertiary (Eocene)</p> <p>$\times \frac{1}{2}$ Magnification</p>	<p>2</p>  <p>Tertiary (Oligocene)</p> <p>$\times 1$ Magnification</p>	<p>3</p>  <p>Jurassic</p> <p>$\times \frac{1}{4}$ Magnification</p>
<p>4</p>  <p>Triassic</p> <p>$\times \frac{1}{2}$</p>	<p>5</p>  <p>Mississippian</p> <p>$\times \frac{1}{2}$</p>	<p>6</p>  <p>Mississippian to Permian</p> <p>$\times \frac{1}{2}$</p>
<p>7</p>  <p>Cambrian</p> <p>$\times \frac{1}{2}$</p>	<p>8</p>  <p>apertural ventral $\times 45$</p> <p>Cretaceous to Holocene</p>	<p>9</p>  <p>Mississippian</p> <p>$\times \frac{1}{4}$</p>
<p>10</p>  <p>Silurian</p> <p>$\times \frac{1}{4}$</p>	<p>11</p>  <p>Ordovician</p> <p>$\times \frac{1}{2}$</p>	<p>12</p>  <p>Devonian</p> <p>$\times \frac{1}{2}$</p>
<p>13</p>  <p>Miocene</p> <p>$\times \frac{1}{2}$</p>	<p>14</p>  <p>side top $\times \frac{1}{2}$</p> <p>Mississippian</p>	<p>15</p>  <p>Ordovician to Devonian</p> <p>$\times 25$</p>
<p>16</p>  <p>Pennsylvanian</p> <p>$\times \frac{1}{2}$</p>	<p>17</p>  <p>Devonian</p> <p>$\times 1$</p>	<p>18</p>  <p>Jurassic to Quaternary</p> <p>$\times \frac{1}{2}$</p>

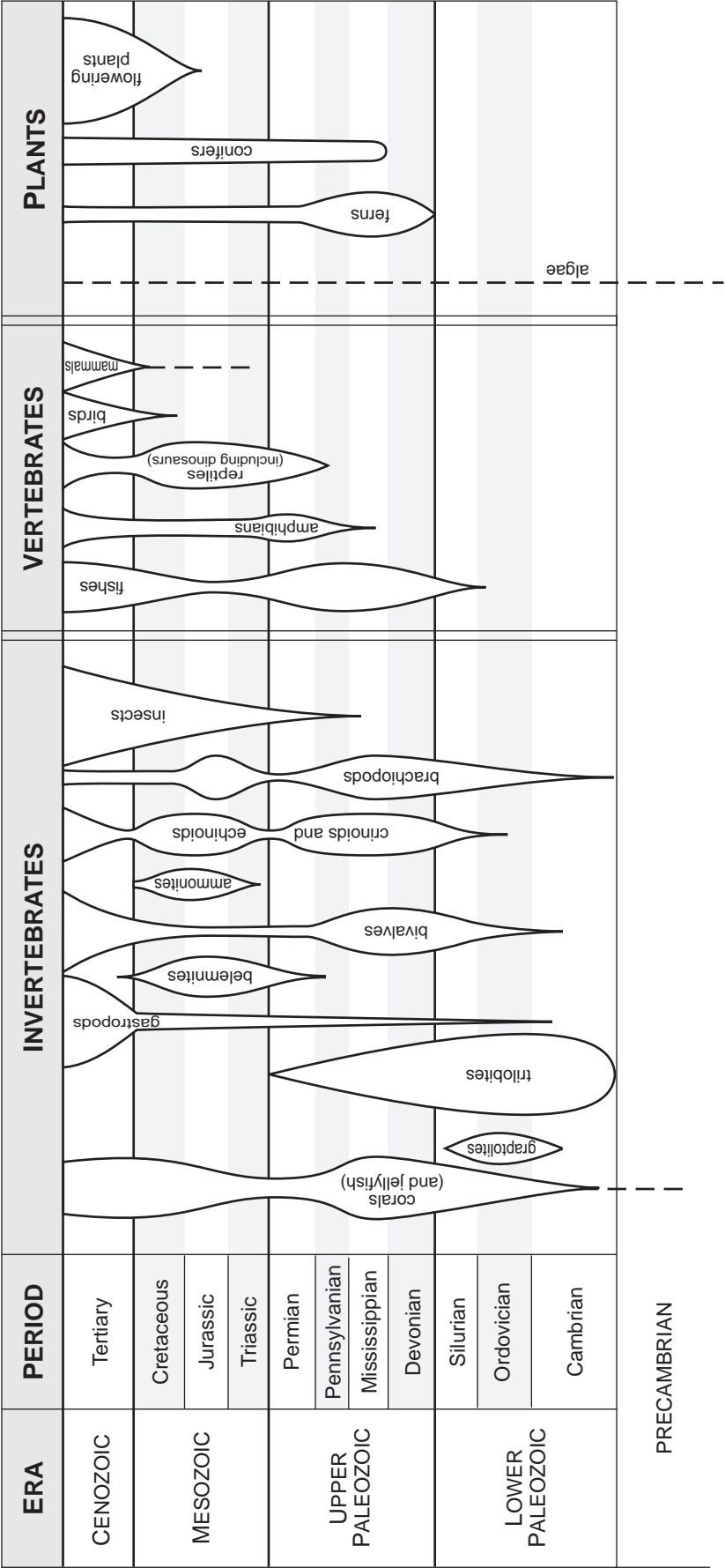
GEOLOGICAL MAP



- Basalt with pillow lavas
- Sandstone
- Black shale
- Limestone
- Siltstone

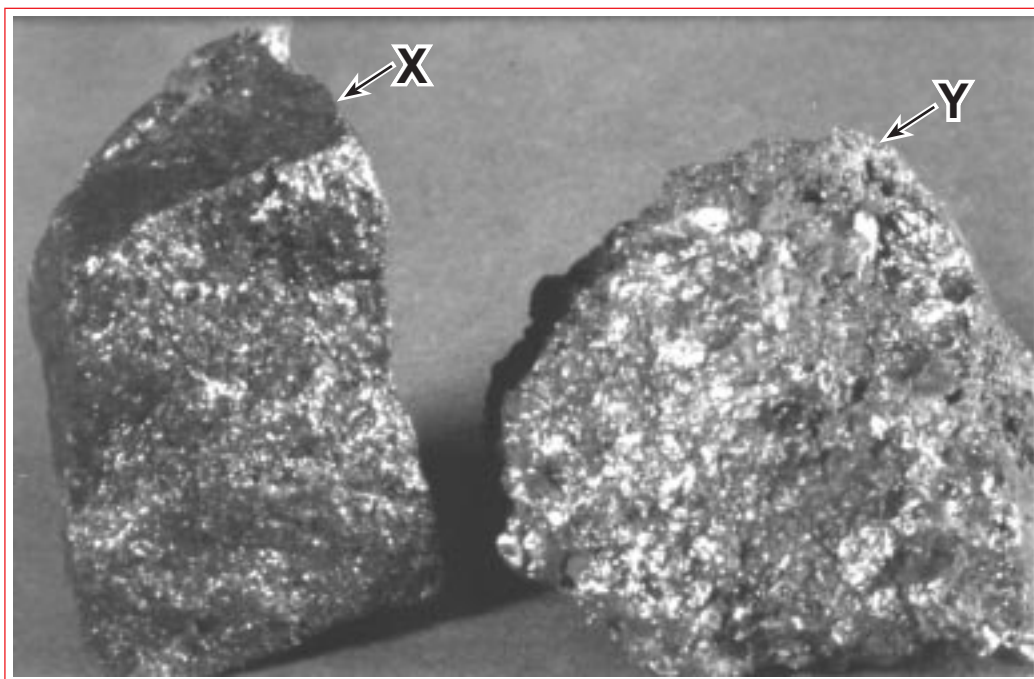
DEVELOPMENT OF LIFE THROUGH TIME

The life-span of each group is shown. The relative abundance of each group is shown by the thickness of the column.

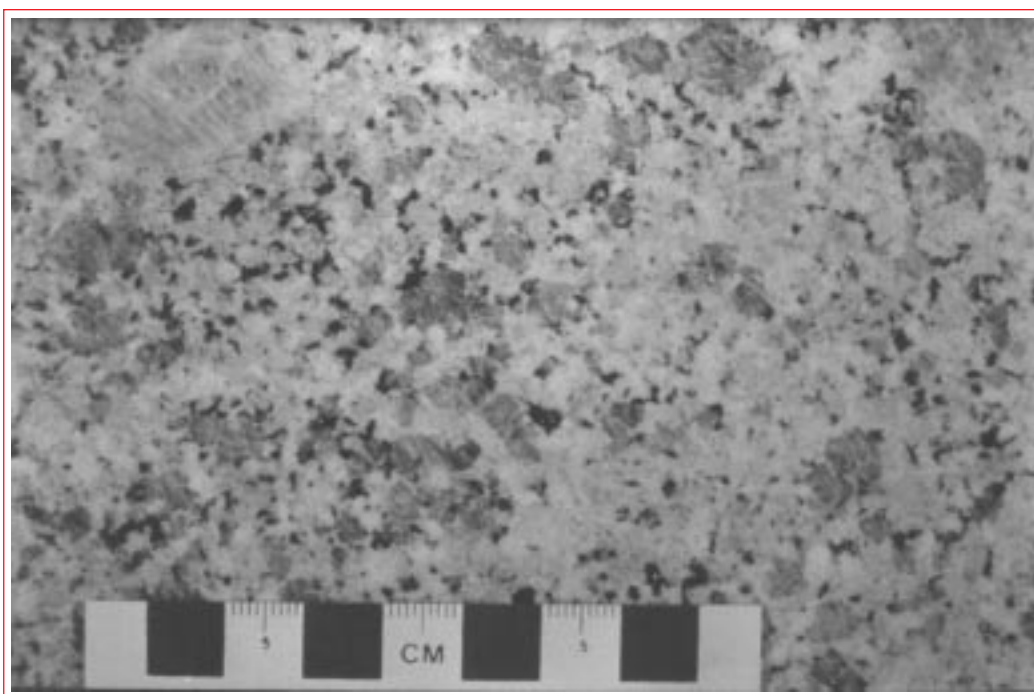


PHOTOGRAPHS

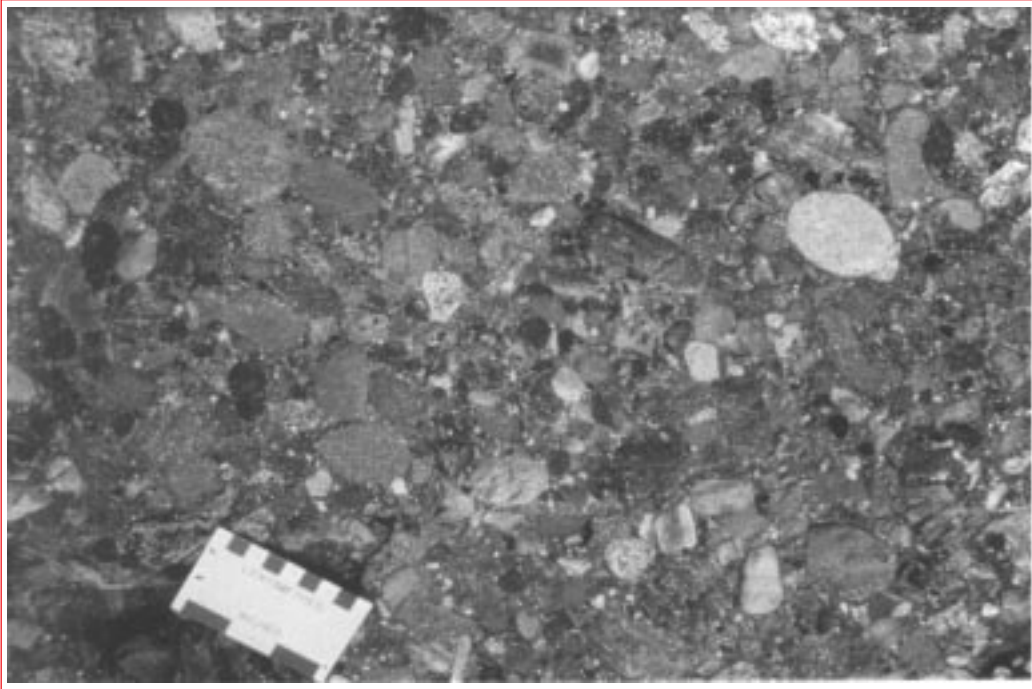
PHOTOGRAPH 1



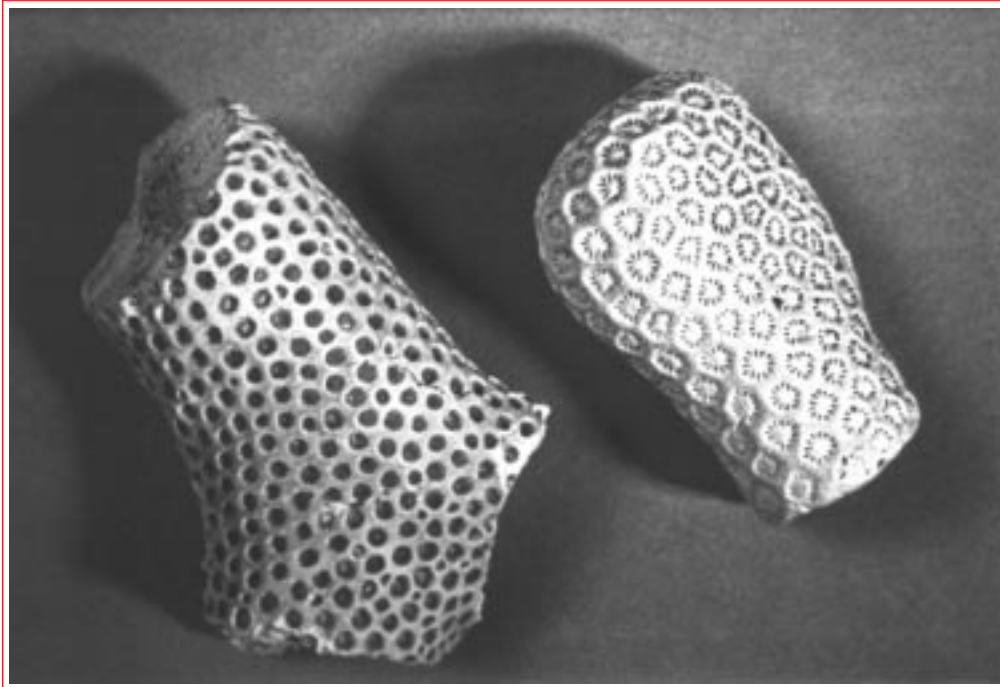
PHOTOGRAPH 2



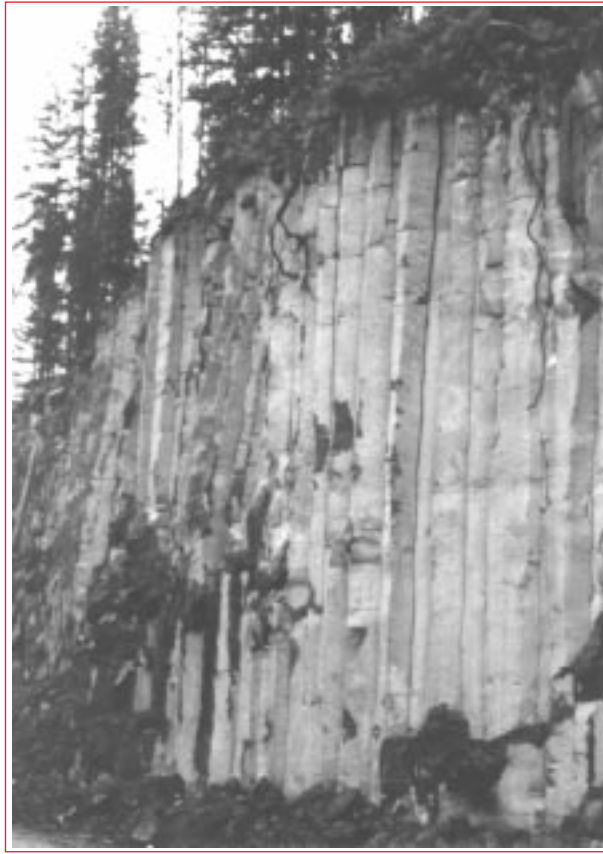
PHOTOGRAPH 3



PHOTOGRAPH 4



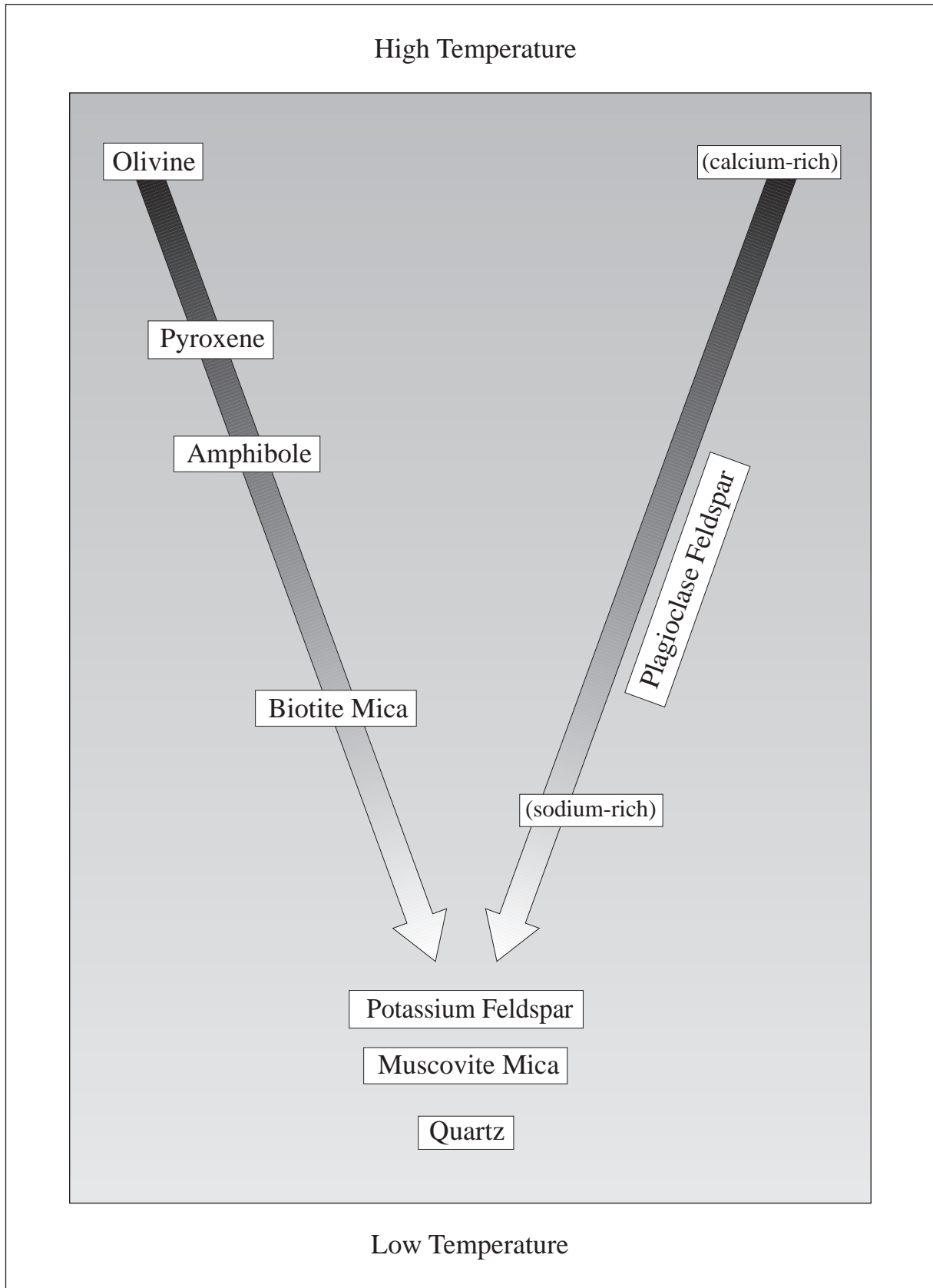
PHOTOGRAPH 5



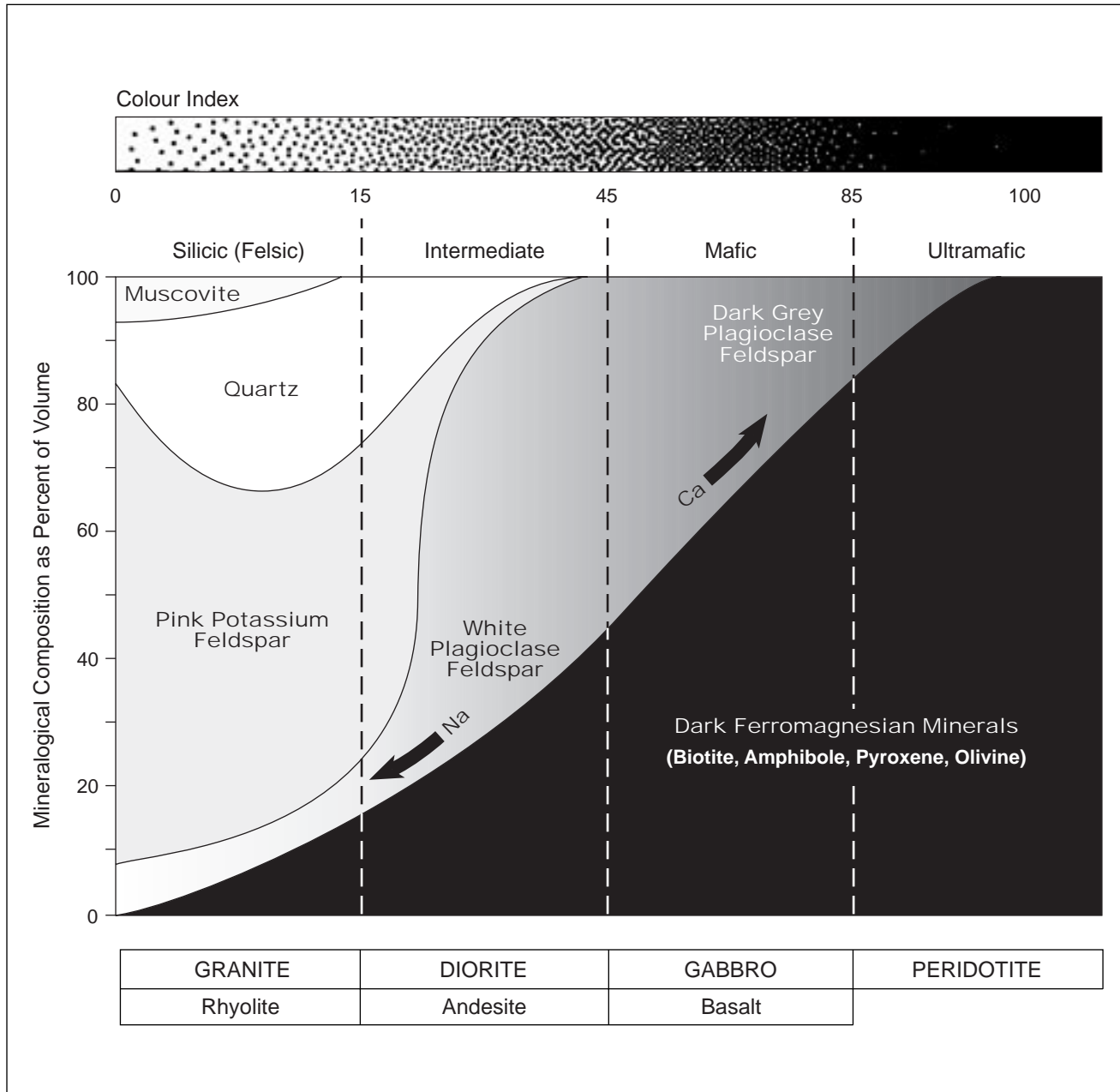
PHOTOGRAPH 6



BOWEN'S REACTION SERIES



PERCENTAGE OF MINERALS IN IGNEOUS ROCKS



BASIC DATA ON THE SOLAR SYSTEM

Planet	Mean Distance From Sun ¹	Equatorial Radius (km)	Mass Relative to Earth ²	Density (g/cm ³)	Number of Moons	Mean Surface Temperature (°C)
Mercury	57.9	2 440	0.0558	5.42	0	350 / –170*
Venus	108.2	6 050	0.8150	5.25	0	475
Earth	149.6	6 378	1.000	5.52	1	22
Earth's Moon	—	1 738	0.012	3.34	n/a	110 / –180*
Mars	227.9	3 397	0.107	3.94	2	–23
Jupiter	778.3	71 400	317.90	1.31	16	–150
Saturn	1 425	60 330	95.15	0.69	22	–180
Uranus	2 870	25 400	14.54	(1.19)	17	–210
Neptune	4 490	24 300	17.23	1.66	8	–220
Pluto	5 900	(1 500)	0.0022	(0.9)	1	–230

¹ In millions of kilometres.

² (mass of planet) / (mass of earth)

* Two surface temperatures are given for Mercury and the Moon because the very slow rotations of these planets result in extreme temperature differences between day and night.

Numbers in parentheses are approximate.

PROPERTIES OF COMMON AND IMPORTANT MINERALS

Mineral	Colour	Streak	Lustre	Form	Cleavage	Hardness	Specific Gravity
Amphibole (hornblende)	dark green to black	white to grey	vitreous	long crystals, grains	2 excellent at 56°	6	3.0 – 3.4
Apatite	usually green	white	vitreous	crystals or massive	1 poor	5	3.1
Asbestos	green or black	none to white	waxy	massive or fibrous	none to fibrous	2.5 – 5.0	3.1
Azurite	blue	pale blue	earthy or vitreous	earthy mass or tiny crystals	seldom visible	3.5 – 4.0	3.8
Bornite	iridescent blue, purple	grey-black	metallic	massive	none	3	5.0
Calcite	white, pink or yellow	white to grey	vitreous	rhombohedral crystals, granular	3 perfect, not at 90°	3	2.7
Chalcopyrite	golden-brassy yellow	black	metallic	tetrahedral crystals, massive	1 poor	3.5 – 4.0	4.2
Chlorite	green to dark green	pale green	vitreous-earthy	scaly masses	1 perfect	2.5	2.6 – 3.3
Feldspar (plagioclase)	white to grey	white	vitreous	tabular crystals, grains	2 excellent at 90°	6	2.6 – 2.8
Feldspar (potassium)	white or pink	white	vitreous-pearly	stubby crystals, grains	2 excellent at 90°	6	2.7
Fluorite	variable: green, purple	white	vitreous	cubic crystals, massive	4 excellent, octahedral	4	3.0 – 3.3
Galena	lead-grey	grey-black	metallic	cubes or massive	3 perfect at 90°	2.5	7.6
Garnet	variable: commonly red	white/pale red	vitreous	12 or 24 faced crystals	none	7	3.6 – 4.0
Gold	gold yellow	yellow	metallic	flakes, grains, massive	none	2.5 – 3.0	19
Graphite	black	dark grey	metallic	massive or scaly masses	1 perfect	1 – 2	2.1
Gypsum	colourless or white	white	vitreous to pearly	tabular crystals or massive	1 excellent, 2 good	2	2.3
Halite	colourless, white	white	vitreous	cubes, massive, granular	3 excellent at 90°	2.5	2.2
Hematite	steel grey, earthy red	red brown	metallic or earthy	scaly or earthy masses	none	5 – 6	5.2
Limonite	brown to yellow brown	brownish yellow	earthy	earthy masses, granular	rarely observable	5.5 – 6.0	3.0 – 4.0
Magnetite	black	black	metallic	commonly massive	seldom visible	5.5 – 6.5	5.0
Malachite	bright green	pale green	earthy	flakes or earthy masses	seldom visible	3.5 – 4.0	3.6 – 4.0
Mica (muscovite, biotite)	white, green, black	white to grey	vitreous	flakes, scaly masses	1 perfect	2.5	2.8 – 3.2
Molybdenite	lead grey, bluish tinge	bluish grey	metallic	scaly masses, flakes	1 perfect	1.0 – 1.5	4.7
Olivine	olive green, olive brown	white, grey	vitreous	granular masses, grains	none	6.5	3.3
Pyrite	brass yellow	greenish black	metallic	cubic crystals or massive	1 very poor	6.0 – 6.5	5.0
Pyroxene (augite)	dark green to black	white-grey	vitreous	stubby crystals	2 excellent at 90°	6	3.3
Pyrrhotite	bronze yellow	grey-black	metallic	usually massive or granular	none	3.5 – 4.5	4.6
Quartz family	variable: clear, white	white	vitreous	prismatic crystals, granular	none	7	2.6
Sphalerite	brown to yellow	yellow to brown	resinous/metallic	tetrahedral crystals, massive	6 perfect	3.5 – 4.0	4.0
Talc	white, pearly	white	waxy, greasy	fibrous, massive	1 perfect	1	2.7 – 2.8